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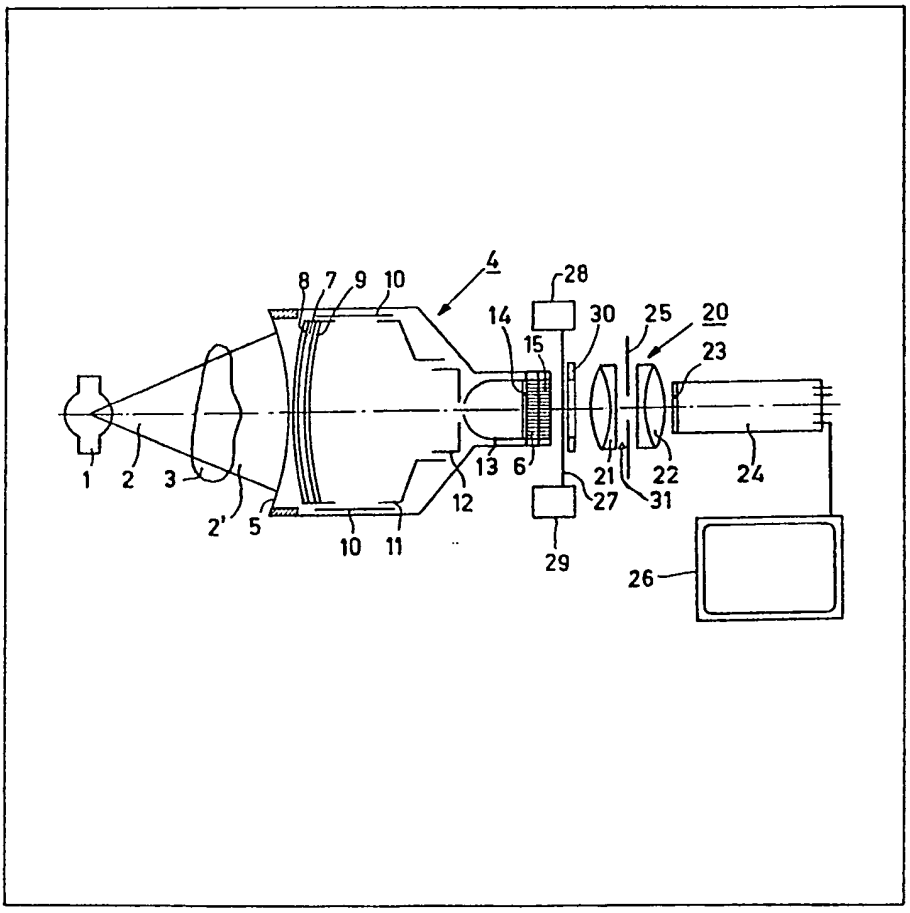
(54) Radiographic apparatus

(57) A combined X-ray fluoroscopy and radiography device includes an X-ray image-intensifier 4, video apparatus 24, 26, means for disposing a photographic film 27, dispensed from feed-spool chamber 28 to take-up chamber 29, in the optical path directly adjacent the intensifier output screen 14, and a ring 30 urging the film against the intensifier exit window during an exposure. The exit window comprises a fibre optic plate 6. To prevent damage, a replaceable fibre optic plate 15 is applied thereto.

Exposure is sensed optically *via* the film, and exposure or video input intensity is adjusted by controlling intensifier gain, e.g. by varying the intensifier accelerating voltage in conjunction with a metal film covering the fluorescent screen 14, whose electron permeability varies by 1:10 for a 1:2 accelerating voltage change.

Auxiliary optical means project identification symbols onto the film 27 and/or camera 24.

The film image can be secured in a window in an indexed card of an addressable indexed-card information storage and retrieval system for addressable retrieval and automatic projection.



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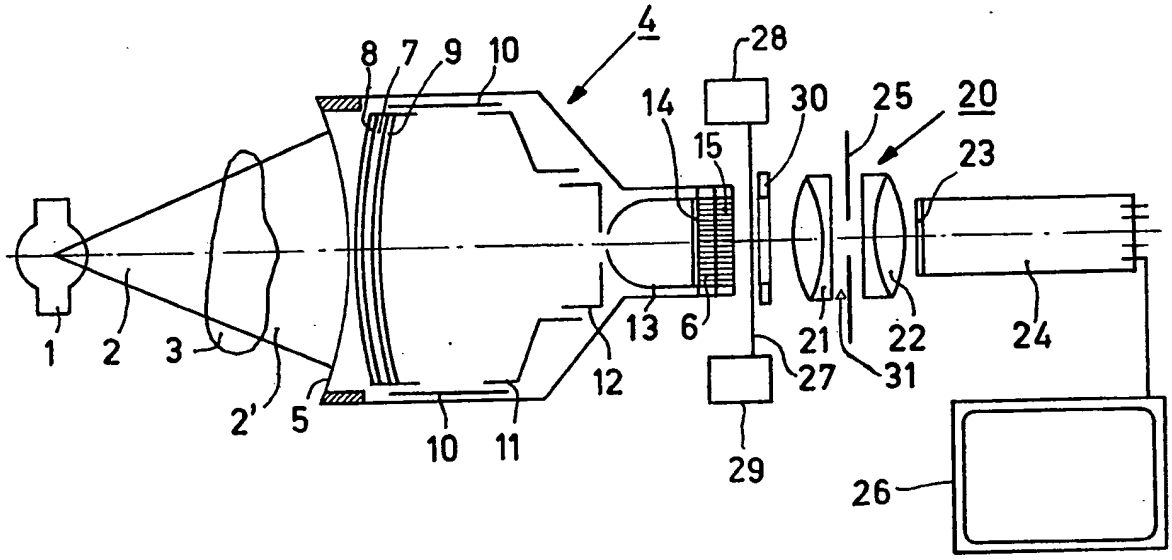

SPECIFICATION

X-ray examination device

The invention relates to an X-ray examination device, comprising an X-ray image intensifier, provided with a fibre-optic exit window, an optical image transfer system, and video apparatus including a television pick-up tube, and will be referred to herein as an X-ray examination device of the kind specified.

An examination device of this kind is known from United States Patent Specification 3,912,936. A device described therein is suitable for medical X-ray examination during which direct visual observation (fluoroscopy) as well as radiographic-image recording photo-radiography are possible. It is customary to project a part of the image-carrying light beam emerging from a lens system, situated between an X-ray image intensifier tube and a television pick-up tube, onto a photographic film, and the remaining part being directed onto the target of the television pick-up tube. For this purpose, use is made of, for example, a semi-transparent mirror or a beam-splitting prism. Particularly for the photographic recording or radiographs on film, a system of this kind requires a comparatively high irradiation energy, if only for a brief period of time. During direct visual observation fluoroscopy, a much lower level of irradiation will suffice, however the duration of this irradiation will be for a much longer time. In principle image information will be lost in both circumstances, both as a result of loss in the distribution optical system (beam-splitter) and/or by a less than optimum operation of the image transferring lens system due to the space which must be provided in the optical path to accommodate the distribution optical system (eg. the beam-splitter).

The invention has for an object to provide an improved X-ray examination device of the kind specified in which a substantially lower radiation dose can suffice, notably for the photographic film recording of radiographic images.

According to the invention there is provided an X-ray examination device of the kind specified, characterized in that means are provided for inserting a photographic film recording medium in the optical path between the optical image transfer system and the X-ray image intensifier, and for urging said medium against the exit window of the X-ray image intensifier during an exposure.

In an X-ray examination device in accordance with the invention, notable when a fibre-optic window is used as the exit window of an X-ray image intensifier, substantially all image information emerging from the X-ray image intensifier tube will be incident on the photographic recording film as a result of the direct contact with the X-ray image intensifier tube during film recording. As a result, an image can be formed even by means of a comparatively small radiation dose, the quantum noise in the image-carring beam usually deciding the lower dose limit.

In a preferred form in accordance with the invention, the optical image transfer system is optimally adapted to the fact that a beam distribution system need no longer be included therein. Therefore, a more compact construction can be realized, in which less vignetting occurs so that an improved image transfer to the television pick-up can be provided. For the control of incident light intensity on the target of the television pick-up tube used, a preferably automatically adjustable diaphragm aperture is included between two parts of the optical system in a preferred arrangement.

In a further form, use is made of a second fibre-optic window which can be readily exchanged so that, should damage occur due to the urging thereagainst of the film material during exposure, it will merely be necessary to replace this second window, while the exit window of the X-ray image intensifier tube can itself remain undamaged.

In a further form, a comparatively small auxiliary optical element is included between two lens parts of the lens system in order to project symbols representing information or an identifying code on, or adjacent the boundary of an image to be recorded on film or sensed by the pick-up tube.

By contrast with known devices, the photographic film medium is arranged in the image-carrying light beam without an intermediate adjustable aperture. One form in accordance with the invention comprises means for controlling the output intensity of the X-ray image intensifier. For this purpose use can be made of, for example, high voltage control of the X-ray image intensifier tube or a channel intensifier plate. Use can alternatively be made of filters, such as grey filters or polarization filters, whereby the amount of light emitted from the X-ray image intensifier can be controlled.

An embodiment of the invention will now be described by way of example, with reference to the accompanying diagrammatic drawing, the single figure of which shows an X-ray examination device embodying the invention. The figure shows an X-ray examination device comprising an X-ray source 1 for generating a beam of X-rays 2 which irradiates an object 3 to be examined, and an X-ray image intensifier tube 4 for intercepting the shadowgraph-image-carring X-ray beam 2. The X-ray image intensifier tube shown comprises a concave entrance window 5 which is preferably made of a metal such as titanium or aluminium, and a fibre optic exit window 6. The tube 4 accommodates a fluorescent screen 7 which is preferably made of TH activated or Na activated CsI which is deposited on a substrate 8. The CsI screen is preferably provided with a structure as described in United States Patent Specification 3,825,763. As a result of the use of the screen structure described therein, optimum resolution can be obtained by the built-in columnar structure in that transverse scattering of emitted light does not occur in the layer, whilst at the same time a high degree of X-ray absorption can be achieved since the layer thickness may be chosen to be

comparatively large, for example, of from 200 to 300 μm. A photo cathode 9 is provided on the fluorescent screen, either with or without an intermediate separating layer. By means of a screen electrode 10, provided between electrodes 11 and 12 and an output electrode 13, an image-carrying electron beam which is formed by the luminous effect of the fluorescence on the photo cathode 9, is focussed on to a fluorescent screen 14 which is preferably provided directly on the exit window. Output brightness control of the X-ray image intensifier tube can be realized, for example, in known manner by variation of the high voltage between the photo cathode 9 and the exit screen 14. It has been found that use can be advantageously made of an X-ray image intensifier tube comprising a thick metal layer on the inner surface of the fluorescent exit screen 14, as described in United States Patent Specification 3,774,038, or of the addition of a channel plate multiplier between the photo cathode and the fluorescent exit screen 14. The use of a channel multiplier plate offers the advantage that it is not necessary to very the high voltage; a comparatively small variation of a voltage applied across the channel plate will suffice for control purposes.

Using an optical system 20, comprising two sections 21 and 22 in tandem, an image transmitted *via* the exit window is focussed on to a target 23 of a television pick-up tube 24. The optical system 20 is preferably constructed so that the beam is parallel between the two sections 21 and 22; as a result, local diaphragm control is possible without giving rise to a significant disturbance of the image. For the purpose of control, an adjustable diaphragm 25 is locally provided, said diaphragm preferably being constructed so as to be automatically adjustable. A video signal derived from the television pick-up tube can be displayed on a monitor 26 for observation.

In the embodiment, photosensitive material 27, for example, a photographic film medium, can be introduced between the exit window of the X-ray image intensifier tube and the first lens 21 of the image transfer optical system. In the present embodiment, a film holder comprising a first chamber 28 for unexposed film and a second chamber 29 for exposed film is included. These film holders may contain a roll of film material as well as a stack of cards provided with film windows. The film material is displaceable therebetween, for example, in the form of a long strip. Use can alternatively be made of loose film plates which are accommodated, for example, as a window in cards of an indexed a card information storage and retrieval system, so that after development and any further treatment, direct filing and later selective retrieval and projection are possible in response, for example, to the application of a coded address. The film medium is arranged, either by slidable or pivotable means to be introduced into the space between the exit window and the lens system, and is urged against the exit window by means of a ring 30 just before and while carring out an exposure. A pressure-exerting mechanism of this kind can be combined with an evacuation device arranged to evacuate the air between the exit window and the film carrier, and this can enable a reliable direct contact there between to be realized. For each film recording, the film medium is inserted into the optical path, clamped to the exit window exposed and then advanced. Cinematrographic recording is also possible in a similar manner. For optimum exposure of the film, one form of the device utilizes the fact that the film medium is always to some extent transparent to the light to be recorded. The transmitted light is intercepted, for example, on the target 23 of the television camera 24 or on a photo cell, and the signal derived therefrom is used in known manner for determining the exposure time for the film recording. The quantity of light to light to be projected onto the television pick-up tube 24 can be controlled by means of the diaphragm 25 which is preferably constructed as an automatically adjustable iris aperture. In another form of the device, and additional optical element 31, for example, a prism, is included for projecting, for example, patient data on an edge portion of a film image to be recorded. When the optical element 31 is constructed as a light distribution system (eg. a beam splitter) this information can be projected both onto the film material and onto the television pick-up tube. The element 31 may be comparatively small and can be arranged so that the image-carrying beam is not disturbed thereby, so that no relevant fluoroscopy data are lost.

Because the photographic recording takes place directly from the exit window of the X-ray image intensifier tube, having a diameter of 25 mm, in one example of an X-ray examination device embodying the invention, not only is the advantage of good sensitivity obtained, but also there can be a substantial saving as regards the amount of film material used. As a result of the absence of a main image distribution system, which when present must be displaced each time between fluoroscopy and recording in some known devices, a device having a high degree of reliability can be realized.

CLAIMS

1. An X-ray examination device, comprising an X-ray image intensifier, provided with a fibre-optic exit window, an optical image transfer system, and video apparatus including a television pick-up tube, characterized in that means are provided for inserting a photographic film recording medium in the optical path between the optical image transfer system and the X-ray image intensifier, and for using said medium against the exit window of the X-ray image intensifier during an exposure.

2. An X-ray examination device as claimed in Claim 1, characterized in that the optical image transfer system combines a compact construction and optimum image transfer.

3. An X-ray examination device as claimed in Claim 1 or 2, characterized in that for controlling the exposure of an image to be recorded, means are provided for sensing light transmitted *via* the film recording medium.

4. An X-ray examination device as claimed in any one of Claims 1, 2 and 3, characterized in that the optical image transfer system includes an optical element for projecting symbols representing additional information onto the film recording medium and/or onto target of the television pick-up tube.

5. An X-ray examination device as claimed in any one of the preceeding claims, characterized in that a further fibre-optic window which is arranged to be exchangeable, is arranged over the external surface of the fibre-optic exit window.

6. An X-ray examination device as claimed in any one of the preceding Claims, characterized in that the gain of the X-ray image intensifier is adjustable.

7. An X-ray examination device as claimed in Claim 6, characterized in that a channel plate electron multiplier is included between the photo cathode of the X-ray image intensifier and the exit fluorescent screen thereof.

8. An X-ray examination device as claimed in Claim 6, characterized in that the exit fluorescent screen of the X-ray image intensifier is provided on its inner surface with a metal layer having an electron transmission factor which decreases by at least approximately a factor of 10 when the operating voltage is reduced to half of a predetermined working value.

9. An X-ray examination device as claimed in any one of the preceding Claims, characterized in that the photographic film recording medium for radiographic image recording comprises portions of film medium provided in window regions in cards which are suitable for use in an indexed card information storage and retrieval system.

10. An X-ray examination device as claimed in Claim 9, characterized in that said device includes an indexed card information storage and retrieval system in which said cards can be selected and the film image held therein can be projected in response to the application of a selection address to said system.

11. An X-ray examination device substantially as herein described with reference to the accompanying drawing.

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